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5158 Blackhawk Road, Aberdeen Proving Ground, Maryland 21010-5403

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Within-year Exertional Heat Illness incidence in U.S. Army Soldiers, 2008-2012

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14. ABSTRACT
The incidence of and risk factors for exertional heat illness (EHI) in the US Army have been well documented. The 'heat season,' when the risk of EHI is highest and application of risk mitigation procedures is mandatory, has been arbitrarily defined as 1 May through 30 September. The proportion of EHI that occur outside of the traditional heat season is unknown. Additionally, it is unknown if the heat season definition is appropriate. **Purpose:** To determine the proportion of EHI that occur within the traditional definition of the heat season at select US Army installations and to examine whether the heat season definition requires revision, Army-wide or on an installation-specific basis. **Methods:** The 10 US

Army installations with the highest frequency of EHI from 2008-2012 were identified and used for analysis. In- and out-patient EHI data (ICD-9-CM codes 992-992.9, first or second diagnoses only) were obtained from the Defense Medical Surveillance System. The summer 'heat season' was operationally defined as 1 May through 30 September; the proportional distribution of EHI within the heat season, overall and by installation was determined. In order to assess the relation between ambient weather conditions and EHI incidence, weather data were downloaded from the National Centers for Environmental Information website and overlaid with weekly EHI incidence plots. Piecewise segmental regression analysis was conducted in order to determine the beginning and end of the heat season for all locations combined and by individual location. **Results:** During the investigation period there were 7,827 EHIs, 79% of which occurred during the heat season. However, between locations there was considerable variability in within heat season EHI frequency, ranging from 70.1% at Ft Bragg to 95.3% at Ft Sill. The locations with the greatest EHI frequency were Ft Bragg (n=2,129), Ft Benning (n=1,560), and Ft Jackson (n=1,538). While the proportional distribution of EHI at Ft Benning and Ft Jackson were similar to the mean, the higher overall frequency resulted in a significant number of EHI cases outside of the heat season. Of the 3,098 cases at those 2 locations, 545, or 8.5 cases/week/installation, occurred outside of the heat season. In contrast, the locations with the lowest frequency were Ft Polk (n=307), Ft Leonard Wood (n=270) and Ft Riley (n=225), where the non-heat season weekly frequency per installation was 1.1 **Conclusion:** These data indicate that EHIs are a year-round problem, with ~17% of all cases occurring during non-summer months, when environmental heat strain and vigilance are lower. This suggests that EHI mitigation policies and procedures require greater year-round emphasis, particularly at certain locations.

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1 Summary

1.1 Overview

Strenuous activity performed over long durations in hot weather increases the risk for exertional heat illness (EHI). Changes in weather patterns directly impact that risk. Currently the U.S. Army defines the "heat season" as 1 May through 30 September each year and requires all Soldiers to undergo heat injury prevention training before 15 April each year.(1-3) This investigation utilized injury data from the Defense Medical Surveillance System (DMSS) and climate data from the National Oceanic and Atmospheric Administration (NOAA) for ten CONUS U.S. Army bases to determine if EHI incidence followed seasonal climate trends and if the burden of EHI was greatest during the defined "heat season." Analysis was also performed to determine demographic risk factors for EHI and compare frequency and rate of injury between bases. Investigation of EHI trends at the bases that commonly have high frequency and/or incidence rate of EHI may help develop more effective EHI prevention programs.

1.2 Purpose

The following report provides analysis of climate and EHI injury data from ten CONUS U.S. Army bases to identify seasonal trends in EHIs and how climactic changes influence EHI occurrence. This analysis also identifies which groups of Soldiers may be more susceptible to EHI and compares EHI frequency and incidence rate at each base investigated.

1.3 Methods

Exertional heat injury data for all active duty U.S. Army Soldiers at ten continental U.S. (CONUS) Army bases between the years of 2008 and 2012 were requested from the Armed Forces Health Surveillance Center (AFHSC). Bases for investigation were identified as locations that have had high frequency of heat injury in recent yearly surveillance reports.(5) The following bases were included in the analysis: Ft Benning, Ft Bragg, Ft Campbell, Ft Hood, Ft Jackson, Ft Leonard Wood, Ft Polk, Ft Riley, Ft Sill, and Ft Stewart. Injuries with primary (first-listed) or secondary (second-listed) diagnoses related to EHI (defined as ICD-9 codes 992.0 through 992.9, inclusive), were included in the request to AFHSC. Denominator data on the number of Soldiers present at each base between 2008 and 2012 were obtained from the Defense Manpower Data Center (DMDC).

Weather data from stations on or near the ten CONUS U.S. Army bases were downloaded from the NOAA website for the same years.(18) EHI injury data was compared to climate data to examine within-season injury trends.

1.4 Results

There were 7,827 new exertional heat illnesses between the years of 2008 and 2012 on the ten CONUS U.S. Army bases investigated. Soldiers who were male (80%), aged 20-29 (60.9%), white, non-Hispanic ethnicity (58.1%), or ranks E1-E4 (76.5%) were most likely to have an exertional heat injury. Overall, 82.3% of all EHIs occurred during the "heat season" of 1 May through 30 September, 10.3% occurred before the season began (1 January – 30 April), and 7.3% occurred after the season ended (1 October -31 December). The bases with the largest proportion of EHI in this sample were Fort Bragg (27.2%), Fort Benning (19.9%), and Fort Jackson (19.6%). The bases with the lowest proportion of EHI in this sample were Fort Leonard Wood (3.4%) and Fort Riley (2.9%). The highest rate of injury (EHI per 1,000 person-months) occurred at Fort Jackson (2.6), Fort Benning (1.3), and Fort Bragg (0.9). Overall, EHIs occurred most frequently during week 31 (August 5-11) of the calendar year. The earliest peak in EHIs occurred during week 24 (June 10-16) at Fort Hood. The latest peak in EHIs occurred during week 34 (August 19-25) at Fort Riley. While the majority of EHIs occurred during the defined "heat season," 29.9% of EHIs at Fort Bragg (15.6% before and 14.3% after) and 16.9% of EHIs at Fort Benning (11.3% before and 5.6% after) occurred outside of the season. Of the 1382 EHI that occurred outside of the heat season, 474 or 34.3% were exertional heat stroke (ICD-9 992.0). In contrast, within the heat season, only 9.1% (587 out of 6445) of all EHI were exertional heat stroke cases.

1.5 Conclusions and Recommendations

These data indicate that the current definition of the 'heat season' is generally appropriate at most US Army installations and that altering it is not warranted at this time. However, the data demonstrate that EHI are a year-round problem, with varying severity depending on the installation. However, as ~17% of all EHI occur outside of the heat season, we recommend that the year-round risk of EHI be included in future heat injury prevention guidance, memorandums and doctrine. Further investigation is warranted regarding ICD-9 diagnostic codes and healthcare providers should be updated on the diagnostic criteria and associated codes for the continuum of heat illnesses.

2 References

See Appendix A for a complete list of reference information.

3 Authority

AR 40-5 'Preventive Medicine' establishes the USAPHC as the Army's Public Health Agency. This investigation falls under chapter 2-19 section *b*-1 of that document authorizing the USAPHC to "[summarize] reportable medical events, injuries, and conditions across installations and commands…"

4 Background

4.1 Mission

The mission of the USAPHC's Injury Prevention Program is to identify causes or risk factors that can be used in evidence-based initiatives to prevent injuries. Analysis of the within-year distribution of Exertional Heat Illness (EHI) incidence will improve understanding of seasonal weather patterns as a risk factor and aid in development of effective EHI prevention programs.

4.2 Oversight

The USAPHC has oversight of this investigation.

4.3 Background

Exertional heat illnesses represent a spectrum of conditions of varying severity, ranging from relatively minor heat cramps and heat exhaustion to more severe illnesses, including potentially-fatal exertional heat stroke. The incidence, severity and risk factors for EHI in military populations have been well-documented. (5, 7, 12) Awareness of the risk of EHI is understandably higher during the summer months, when exposure to environmental heat stress is greater. As a result, all Army units are required to conduct EHI prevention training by 15 April of each year, in preparation for the 'heat season,' which has been arbitrarily defined as 1 May to 30 September of each year.(1, 2) While the rationale supporting these dates may be appropriate, a false sense of security may result, in which Soldiers and leaders at all levels are not aware that EHI may occur at any time of year. The proportion of EHI that occur outside the bounds of the heat season is unknown.

The continental United States climate is widely diverse, as are the demographic characteristics and activities of Soldiers at various installations. It would be inappropriate to assert that environmental heat stress is similar at Ft Jackson SC and Ft Riley KS. Likewise, an initial entry Soldier is typically less-fit than a Soldier after several years of service and training and physical fitness confers some degree of heat acclimatization (20) and may be protective against EHI.(12) Therefore, it may be inappropriate to assume that risk of EHI across installations with different types (training vs operational forces) of units.

Recent data indicates that there are over 1,200 incident cases of EHI in the Army each year, which may result in significant lost duty time, medical care costs and eligibility for continuation of service.(5, 10) Additionally, from 1980 to 2002 at least 37 Soldiers died as a result of an EHI.(7) Individual risk factors for EHI include poor fitness, increased body mass index, use of certain medications, lack of acclimatization to the heat, hypohydration, skin disorders and concurrent illness with fever or inflammation.(9) Other risk factors include the environmental conditions, as indicated by the wet bulb globe temperature (WBGT) index, clothing worn, equipment carried, and work intensity. Due to clothing, equipment and/or work intensity factors, it is not uncommon for EHI to occur at times other than the hottest months of the year. However, the variation of the frequency and incidence rate of EHI within a given calendar year is unknown.

Therefore, the purpose of this study was to determine the within-season distribution of EHI at ten CONUS Army installations, in order to calculate the proportion of EHI that occurred within and outside the heat season.

5 Methods

5.1 Data Collection

Demographic and injury visit data (inpatient and outpatient) for all exertional heat injuries among active duty U.S. Army Soldiers at ten CONUS Army bases between the years 2008 and 2012 were acquired from the Defense Medical Surveillance System (DMSS), maintained by the Armed Forces Health Surveillance Center (AFHSC). Exertional heat illnesses were defined as any medical encounter with a primary or secondary diagnosis with ICD-9 codes 992 through 992.9, inclusive. Data obtained from DMSS included study ID number, age, sex, race/ethnicity, rank, unit location at time of injury, and primary and secondary diagnosis codes. The ten bases included in the investigation were Fort Benning, Fort Bragg, Fort Campbell, Fort Hood, Fort Jackson, Fort Leonard Wood, Fort Polk, Fort Riley, Fort Sill, and Fort Stewart. These bases were chosen for investigation because they have consistently had high frequency of EHI in previous years.(5) Data on troop strength at each location by month, sex, and rank (enlisted versus officer) were obtained from the Defense Manpower Data Center (DMDC). Due to the small number of Warrant Officers in the U.S. Army, person time data for Commissioned and Warrant Officers were collapsed.

Climate data from weather stations located on or near each of the ten bases were obtained from the National Oceanic and Atmospheric Administration (NOAA) website. At each of these stations, weather data is collected and stored several times a day. Weather station data include date and time of each observation and various climate data, including dry and wet

bulb temperature (Celsius and Fahrenheit), dew point, relative humidity, wind speed, precipitation, and sea level pressure. For this investigation only dry- and wet-bulb temperatures were analyzed.

5.2 Data Analysis

EHI database

Exertional heat illness data for the years 2008 through 2012 at 10 CONUS bases were requested from AFHSC. Most Soldiers require one or more follow-up visits after an initial heat injury diagnosis. To distinguish between "new" and "follow-up" injury events, affected Soldiers were not considered at risk for "new" EHIs within 60 days of prior heat injury events. It is possible that each Soldier may have experienced more than one "new" heat injury over the study period if the injury diagnosis date was more than sixty days apart. These criteria are consistent with other military heat injury surveillance documents.(5) A new variable was created on diagnosis date to determine if the EHI occurred before, during, or after the heat season (defined as 1 May - 30 September). Frequency and percent distribution of EHI injury were calculated for age, sex, rank, race, and unit location at time of injury. The percent distribution, grouped by exertional heat stroke (ICD-9 992.0) vs all other types of EHI (ICD-9 992.1-992.9, inclusive), was also calculated.

Injury rates were calculated for each of the 10 bases, by week, using denominator data obtained from DMDC. Since denominator data from DMDC was provided by month, rates for each week were calculated using injury data from each week and denominator from the corresponding month (i.e. week 26 was in month 6; see Appendix B). Overall EHI rates for sex and rank (enlisted versus officer) were also calculated. Rates were calculated as # of injuries per person-months.

Climate Database

After climate data was downloaded from the NOAA website, new variables for wind speed (converted from mph to kph), wind chill, minimum temperature, and modified discomfort index (MDI;(17)) were created. Wind speed (in kph) was calculated as wind speed (in mph)*1.61. Wind chill was calculated for all climate samples with a dry bulb temperature (in °C) of less than 10 and a wind speed (in kph) of greater than 4.8 as WindChill=13.12 + 0.6215 * DryBulbCelsius - 11.37 * Windspeed_Kph** 0.16 + 0.3965 * DryBulbCelsius * Windspeed_Kph ** 0.16. Dry bulb temperatures (in °C) and wind chill temperatures (in °C) were compared and whichever was lowest was recorded as the minimum temperature. MDI was calculated as MDI=0.25*DryBulbCelsius + 0.75*WetBulbCelsius.

Combined Analysis

After all new variables were created in the EHI and climate databases, graphs were created by combining EHI and climate data. EHI rates, mean dry bulb temperature (in °C), and mean wet bulb temperatures (in °C), by week, were graphed for overall data and for each

base separately. Stacked area graphs of the injury rate, by week, were created to show the distribution of EHIs for each base as a total of all EHIs over the 5 year study period. Separate graphs were created to reflect the distribution of EHI by frequency and rate. Segmental (piecewise) regression was used to determine the critical cut-points at which trends in EHIs significantly increased or decreased.(8) Analysis was performed separately on data from week 1 to week 30 (the peak heat injury week) in order to determine when the "heat season" should begin and from week 31 to week 52 to determine when the "heat season" should end. Statistical analysis was performed using Microsoft Excel 2010, SigmaPlot Version 12.3 and The Statistical Package for the Social Sciences (SPSS®), Version 21.

6 Results

6.1 Descriptive Results—Demographics

The total number of Soldiers who experienced a "new" heat injury at the 10 bases between 2008 and 2012 was 6,838; with a total of 7,827 qualifying EHI events. There were 5,388 males and 1,450 females injured over the investigation period. The demographic characteristics of those who suffered an EHI are shown in Table 6.1.

Table 6.1 Demographics of Soldiers Who Experienced an EHI, 2008-2012 (n=6,838)

Variable	Variable Level	n	% injured
Sex	Male	5388	78.8
	Female	1450	21.2
Age	<20	1674	24.5
	20-29	4073	59.6
	30-39	895	13.1
	40+	196	2.9
Race/Ethnicity	Unknown	789	11.5
	White, non-Hispanic	3891	56.9
	Hispanic	595	8.7
	Black, non-Hispanic	1292	18.9
	Asian/Pacific Islander	271	4.0
Rank	E1-E4	5295	77.4
	E5-E9	1005	14.7
	O1-O5	517	7.6
	O6-O10	2	0.0
	W1-W5	22	0.3

6.2 Descriptive Results—Location

The frequency and incidence rate, by location, are shown in Figures 6.1 and 6.2,

respectively. Two-thirds of all EHI in this sample occurred at Fort Bragg (27.2%), Fort Benning (19.9%), and Fort Jackson (19.6%). No other installation accounted for more than 10% of the total.

Figure 6.1 Frequency of EHI by location, US Army, 2008-2012

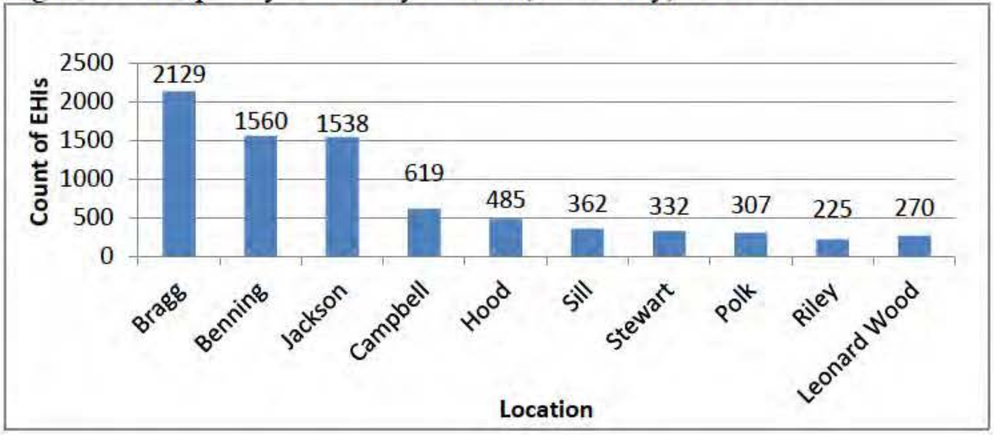
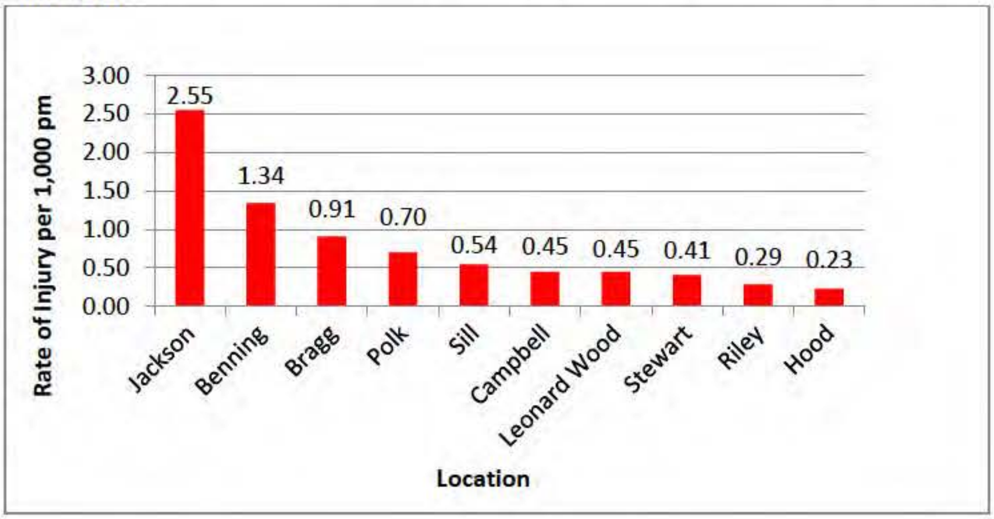


Figure 6.2 Incidence rate of EHI (injuries per 1,000 person-months) by location, US Army, 2008-2012



6.3 Descriptive Results—Injury Trends by Year, Month and Week

The year with the highest rate of EHIs was 2011 (n=1,924, 0.87 per 1,000 person-months) and the year with the lowest rate of EHI was 2009 (n=1,258, 0.57 per 1,000 person-months). Overall, the highest rate of EHI occurred during the month of July (n=2,011, 2.23 per 1,000 person-months) and the week of 30 July - 5 August (week 31, n=546, 7.0%) had the largest number of injuries. EHI occurred the least frequently during the month of

December (n=84, 0.09 per 1,000 person-months) and the week of December 24th-31st (week 52, n=8, 0.1%) had the fewest heat injuries. The majority (n=6,445, 82.3%) of EHIs were diagnosed during the "heat season" of 1 May - 30 September, while 10.3% occurred before the heat season started (1 January- 30 April) and 7.3% occurred after the heat season ended (1 October- 31 December). Pre- and post-season EHI were most frequent at Fort Bragg (15.6% and 14.3% respectively).

Figure 6.3 Overall Rate of EHI in the US Army (injuries per 1,000 person-months) by year

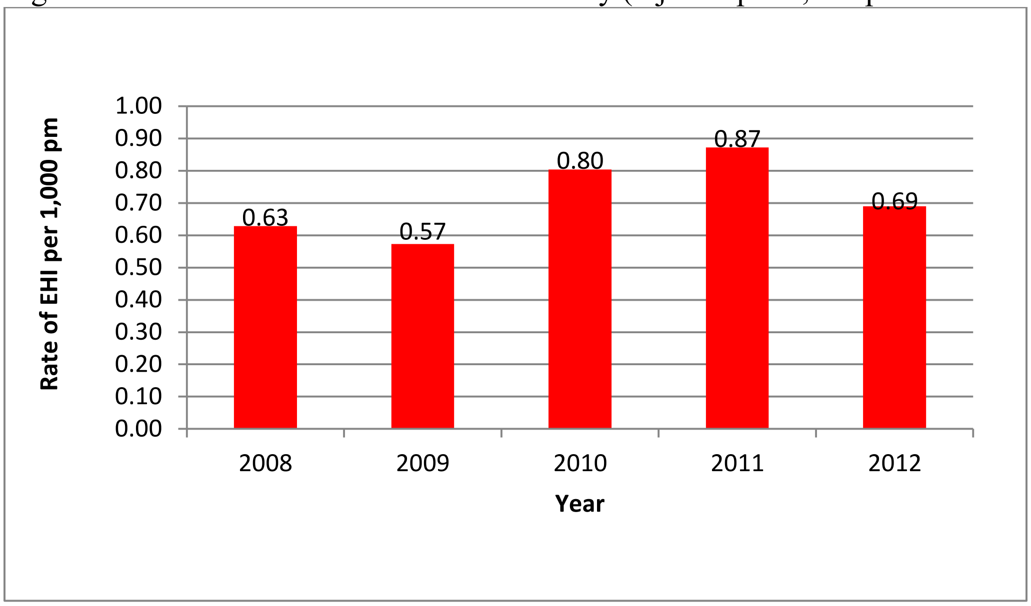


Figure 6.4 Overall Rate of EHI (injuries per 1,000 person-months) by month, US Army, 2008-2012

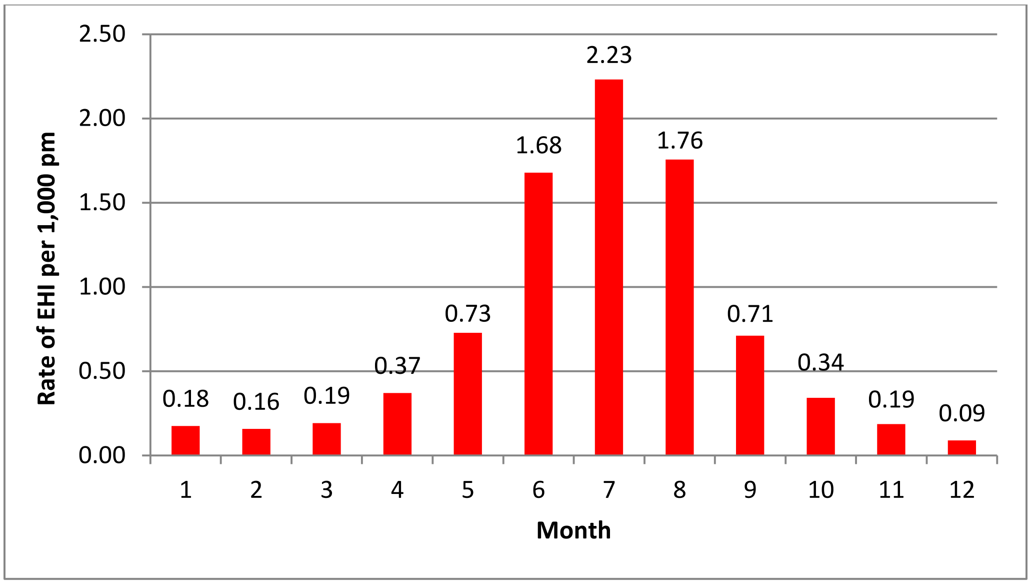


Figure 6.5 Overall Rate of EHI (injuries per 1,000 person-months) by week

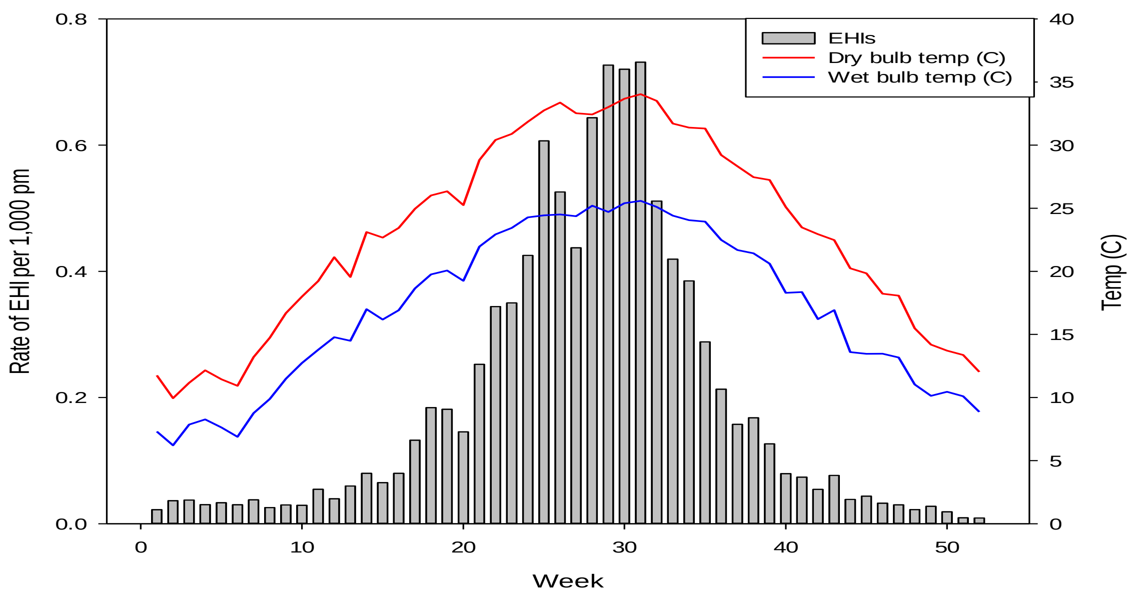


Figure 6.6 Overall Frequency of EHI by injury type

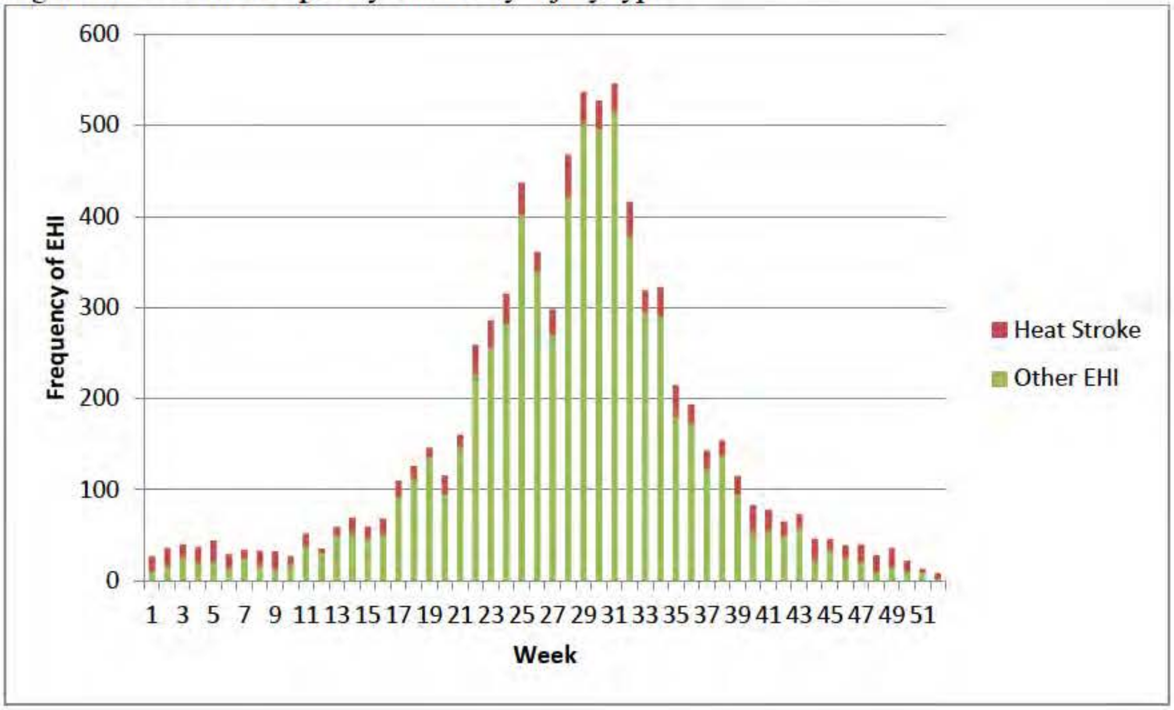


Table 6.2 Percent of EHIs Occurring Before, During or After the Heat Season of 1 May – 30 September, by location

Location	Before (%)	During (%)	After (%)
Fort Benning	11.3	83.1	5.6
Fort Bragg	15.6	70.1	14.3
Fort Campbell	9.4	86.4	4.2
Fort Hood	10.5	82.3	7.2
Fort Jackson	7.6	89.1	3.3
Fort Leonard Wood	4.1	92.6	3.3
Fort Polk	5.5	89.9	4.6
Fort Riley	5.3	87.6	7.1
Fort Sill	2.8	95.3	1.9
Fort Stewart	7.8	85.2	6.9
Overall	10.3	82.3	7.3

Table 6.3 Percent of Heat Stoke Injuries Occurring Before, During or After the Heat Season of 1 May – 30 September, by location

Location	N	Before (%)	During (%)	After (%)	% of total EHI
Fort Benning	110	14.5	70.9	14.5	7.1
Fort Bragg	727	27.0	50.6	22.4	34.2
Fort Campbell	60	26.7	60.0	13.3	9.7
Fort Hood	57	15.8	70.2	14.0	11.8
Fort Jackson	12	8.3	66.7	25.0	0.8
Fort Leonard Wood	12	25.0	50.0	25.0	4.4
Fort Polk	18	33.3	55.6	11.1	5.9
Fort Riley	14	7.1	78.6	14.3	6.2
Fort Sill	14	28.6	57.1	14.3	3.9
Fort Stewart	37	13.5	59.5	27.0	11.2
Overall	1061	24.2	55.3	20.5	13.6

6.4 Descriptive Results—Injury Trends by week, by location

The following two figures expand upon the data shown in Table 6.2, to graphically represent the proportion of EHI, by location, on a week-by-week basis.

Figure 6.7 Percent Total EHIs at Each Location by Week Calculated Using Injury Frequency, US Army, 2008-2012

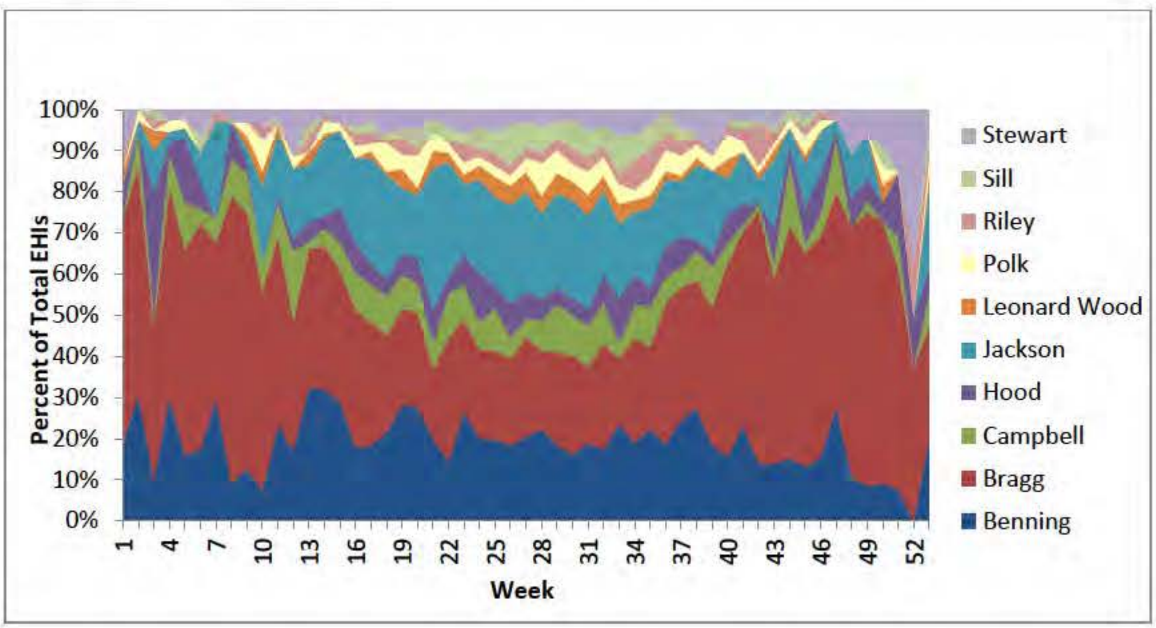
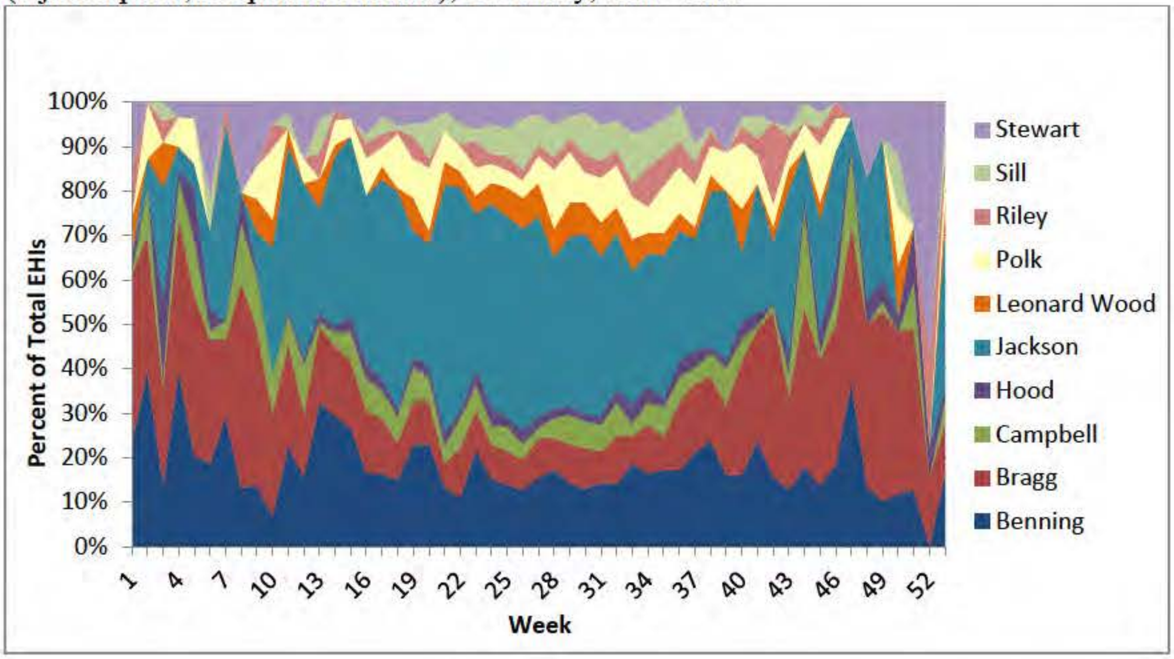


Figure 6.8 Percent Total EHIs at Each Location by Week Calculated Using Injury Rate (injuries per 1,000 person-months), US Army, 2008-2012



The following 10 figures (6.9A - 6.9J) present the incidence rate of EHI, expressed per 1,000 person-months, at each of the 10 individuals locations analyzed.

Figure 6.9A Fort Benning, GA, EHI incidence rate by week, 2008-2012

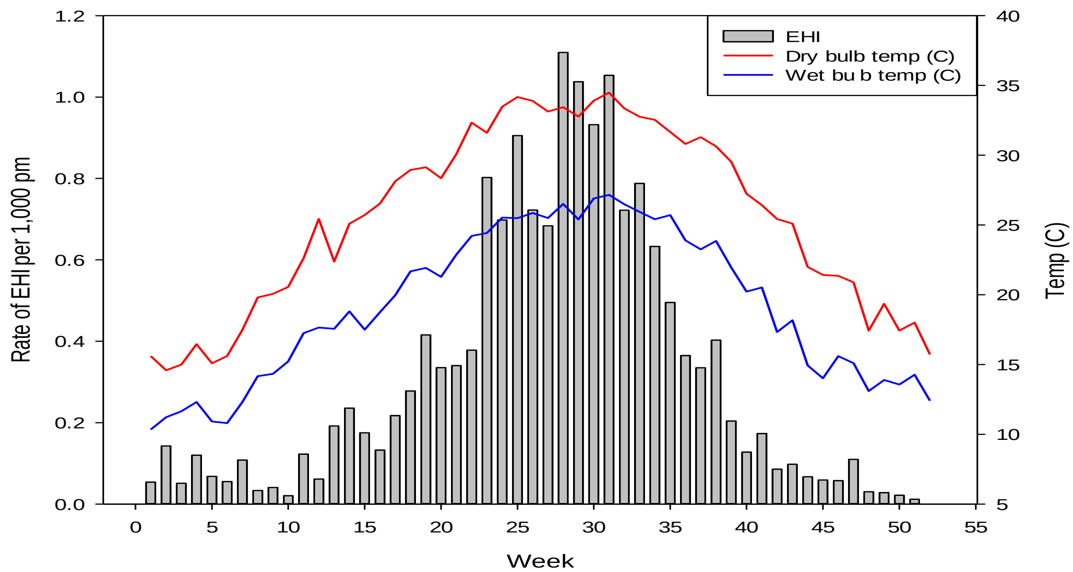


Figure 6.9B Fort Bragg, NC, EHI incidence rate by week, 2008-2012

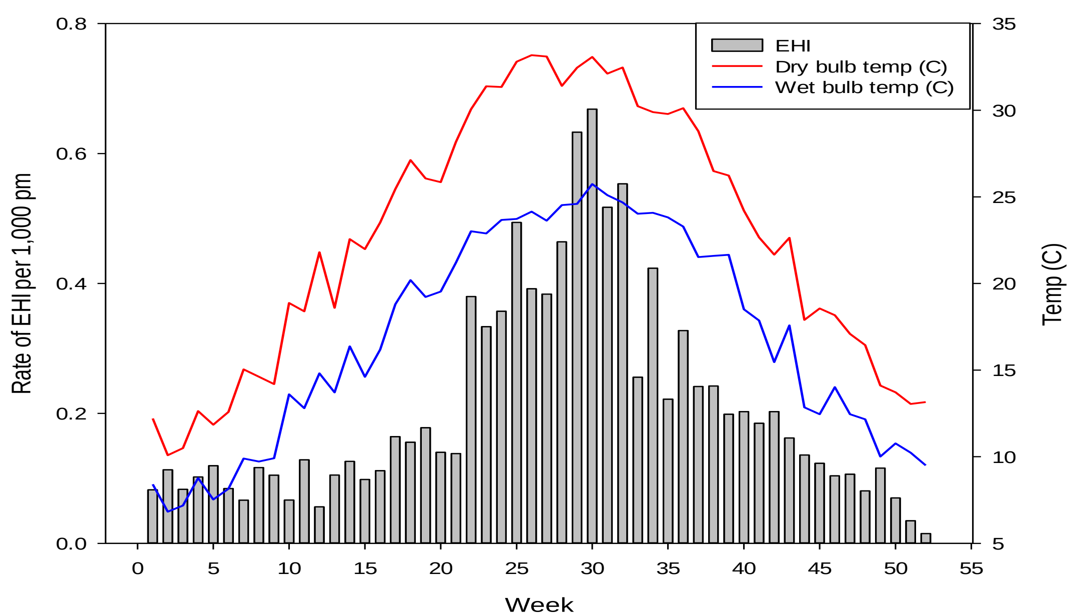


Figure 6.9C Fort Campbell, KY, EHI incidence rate by week, 2008-2012

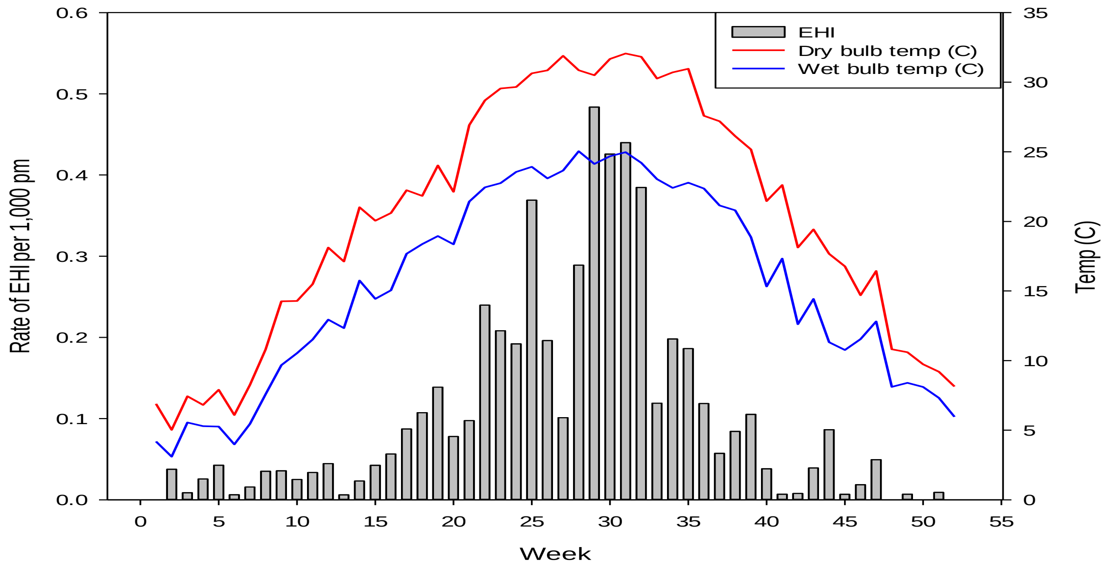


Figure 6.9D Fort Hood, TX, EHI incidence rate by week, 2008-2012

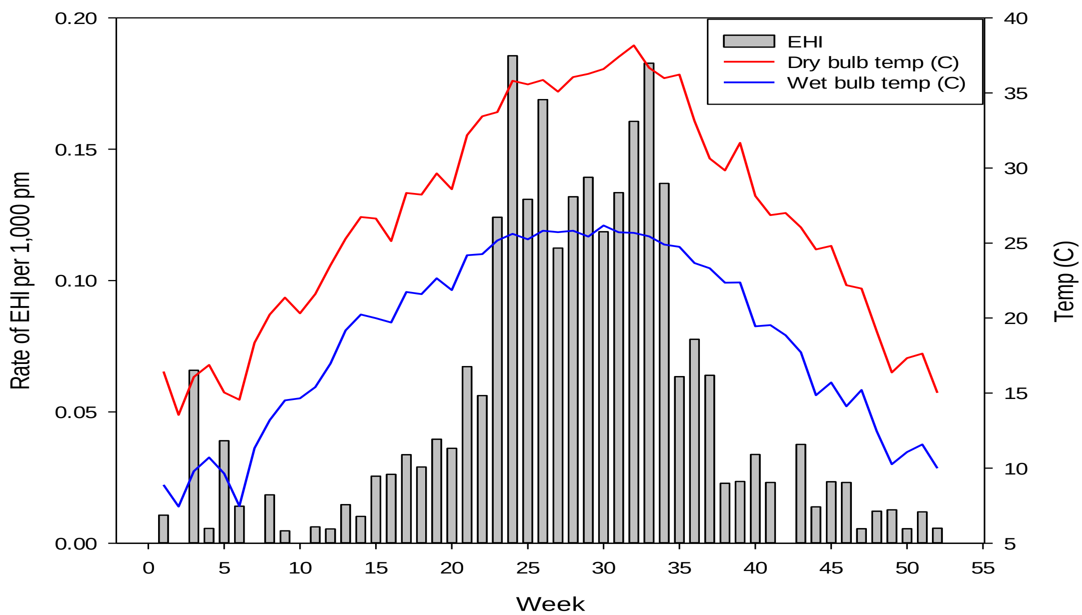


Figure 6.9E Fort Jackson, SC, EHI incidence rate by week, 2008-2012

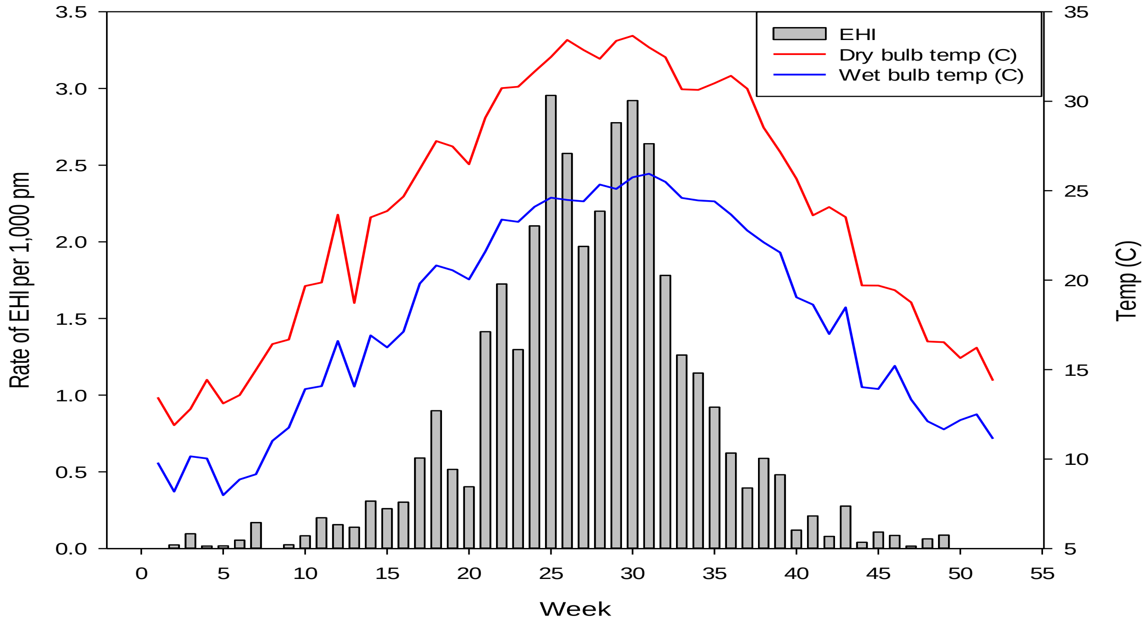


Figure 6.9F Fort Leonard Wood, MO, EHI incidence rate by week, 2008-2012

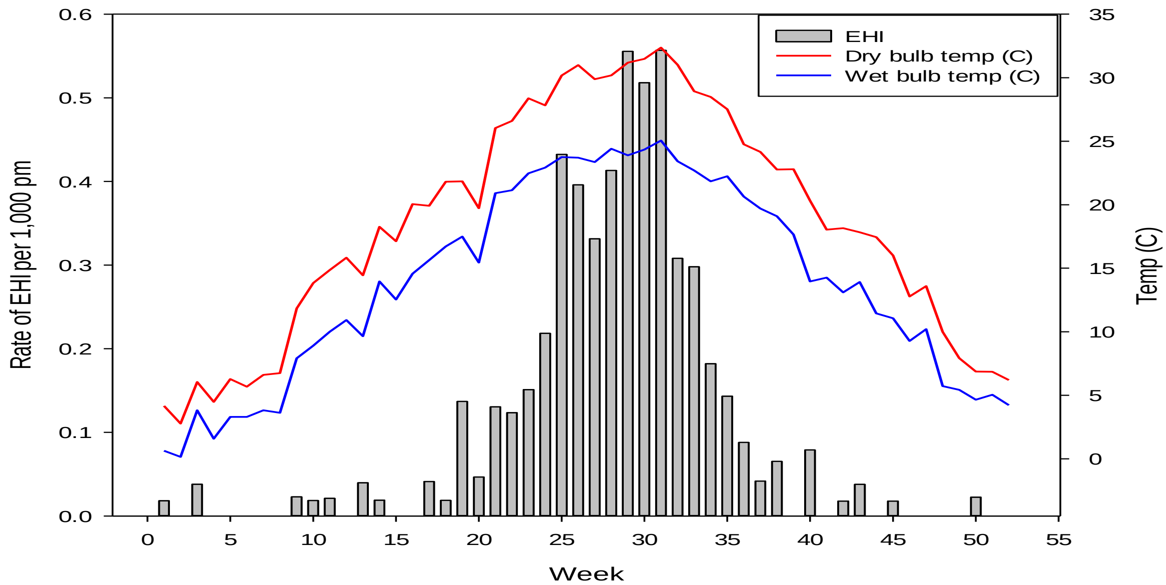


Figure 6.9G Fort Polk, LA, EHI incidence rate by week, 2008-2012

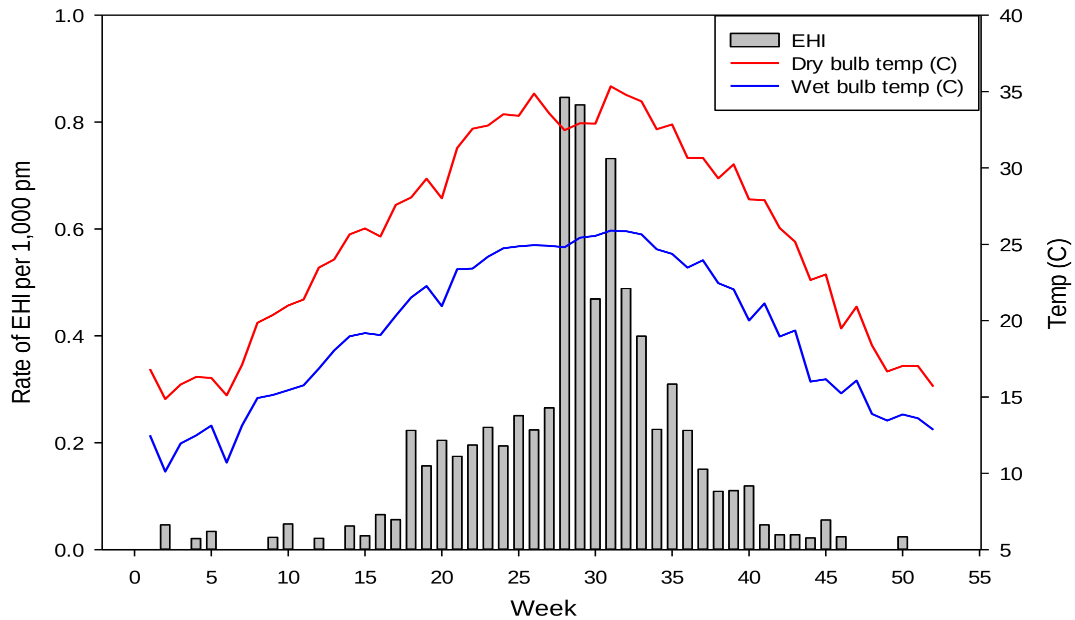


Figure 6.9H Fort Riley, KS, EHI incidence rate by week, 2008-2012

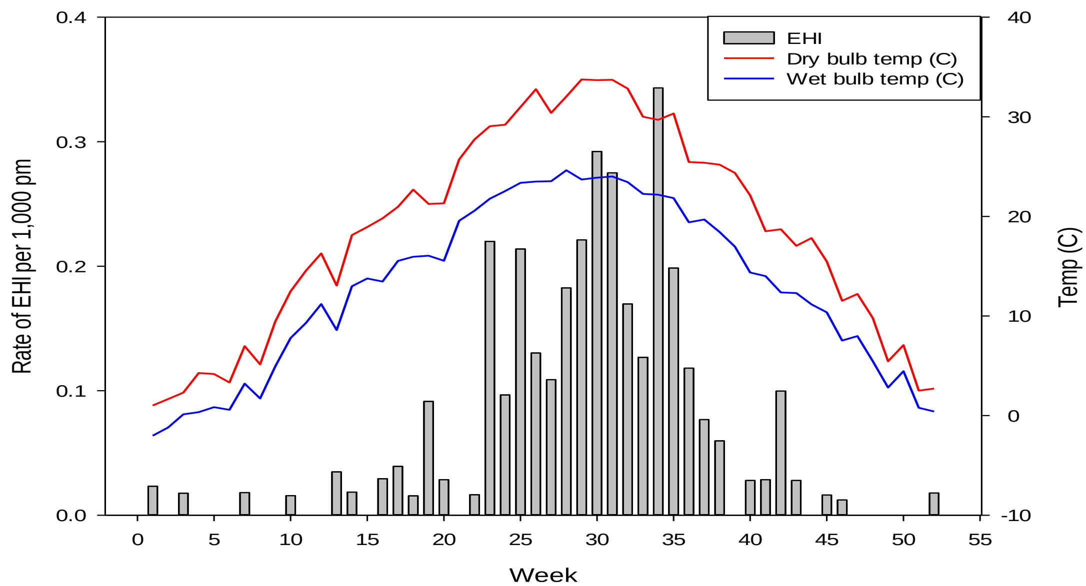


Figure 6.9I Fort Sill, OK, EHI incidence rate by week, 2008-2012

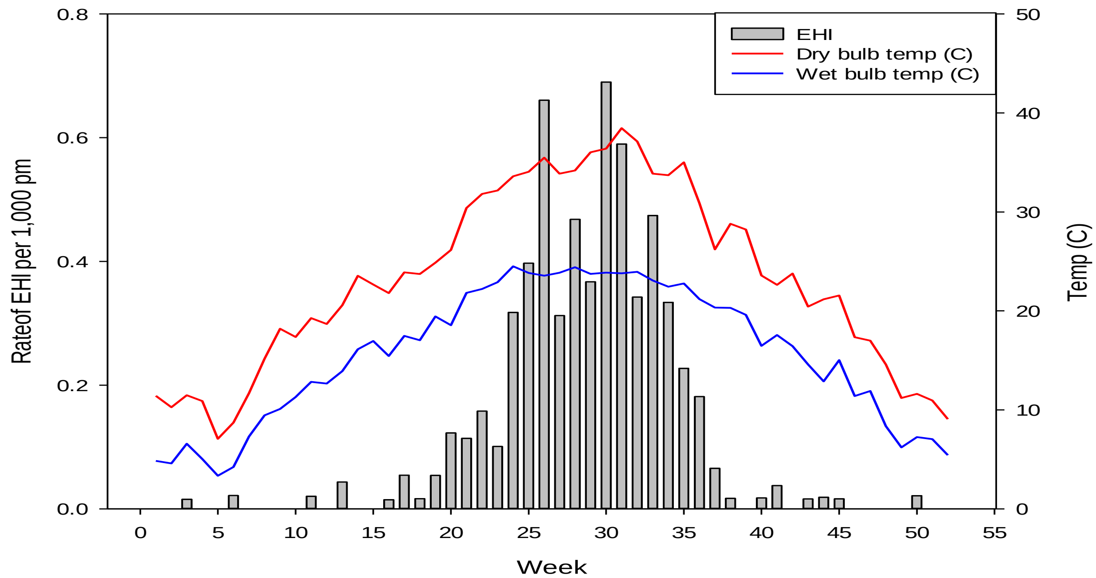
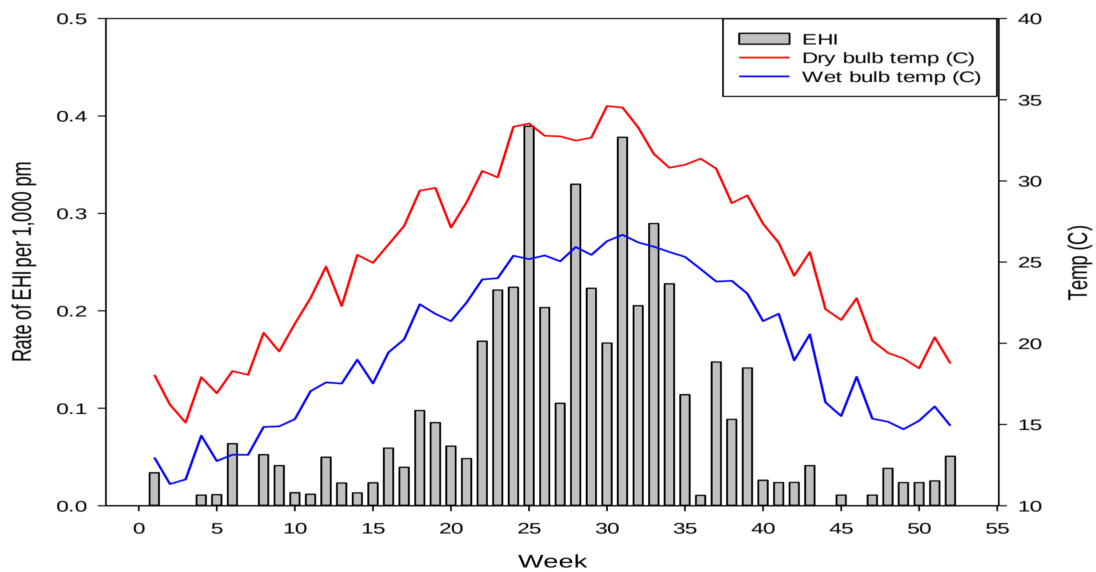


Figure 6.9J Fort Stewart, GA, EHI incidence rate by week, 2008-2012



6.5 Piecewise regression results

Piecewise regression was performed on the entire dataset and by location, in order to determine if the 'heat season' definition of 1 May – 30 September is appropriate. The results are

summarized in Table 6.4 and displayed graphically, overall and by location, in Figures 6.10 and 6.11A – 6.11J, respectively.

Table 6.4. Piecewise regression cut-points, by location, US Army, 2008-2012. The earliest cut-point occurred at Fort Hood and the latest at Fort Stewart.

Location	Heat season starting week	Heat season ending week
Fort Benning	16	39
Fort Bragg	19	33
Fort Campbell	17	36
Fort Hood	14	39
Fort Jackson	16	36
Fort Leonard Wood	19	36
Fort Polk	17	37
Fort Riley	19	39
Fort Sill	19	38
Fort Stewart	15	41
Overall	17	37

Figure 6.10 Piecewise linear regression, all locations, demonstrating that the start of the heat season, based on an increased EHI incidence, occurred at the beginning of week 17 (April 23-29) and the end of the heat season occurred at the beginning of week 37 (Sept. 10-Sept. 16).

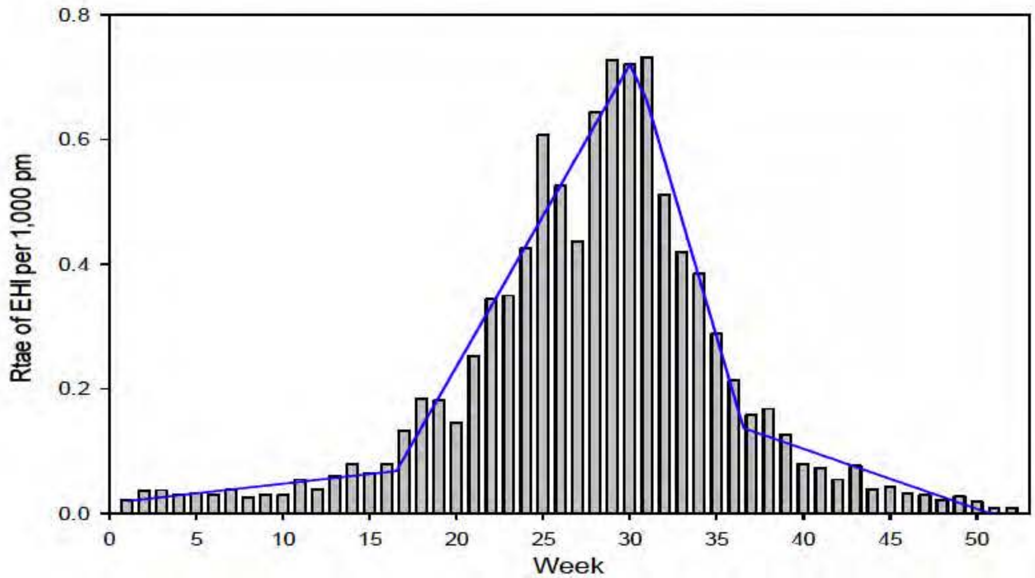


Figure 11A Piecewise linear regression, Fort Benning, GA, 2008-2012

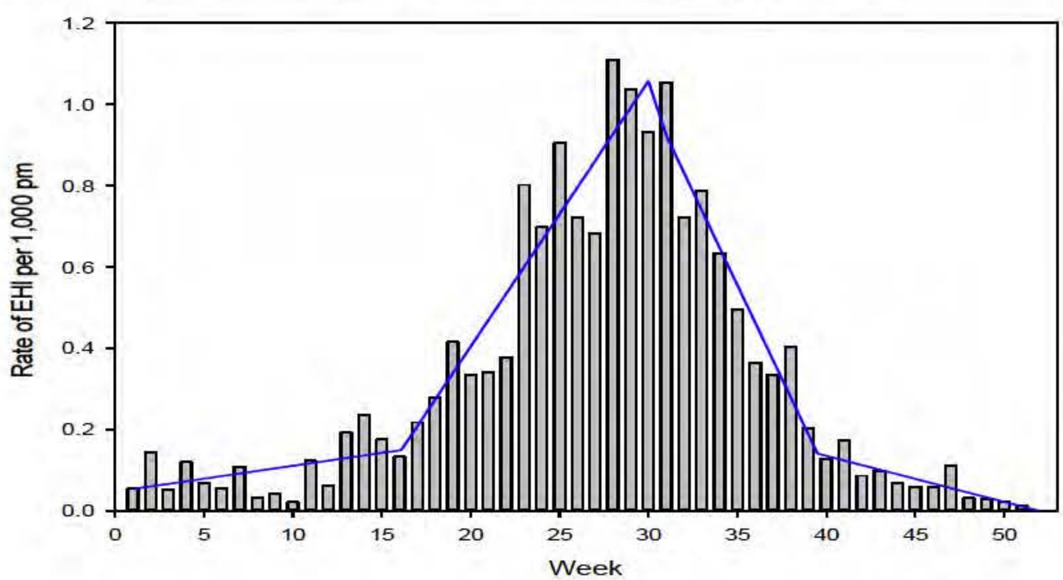


Figure 11B Piecewise linear regression, Fort Bragg, NC, 2008-2012

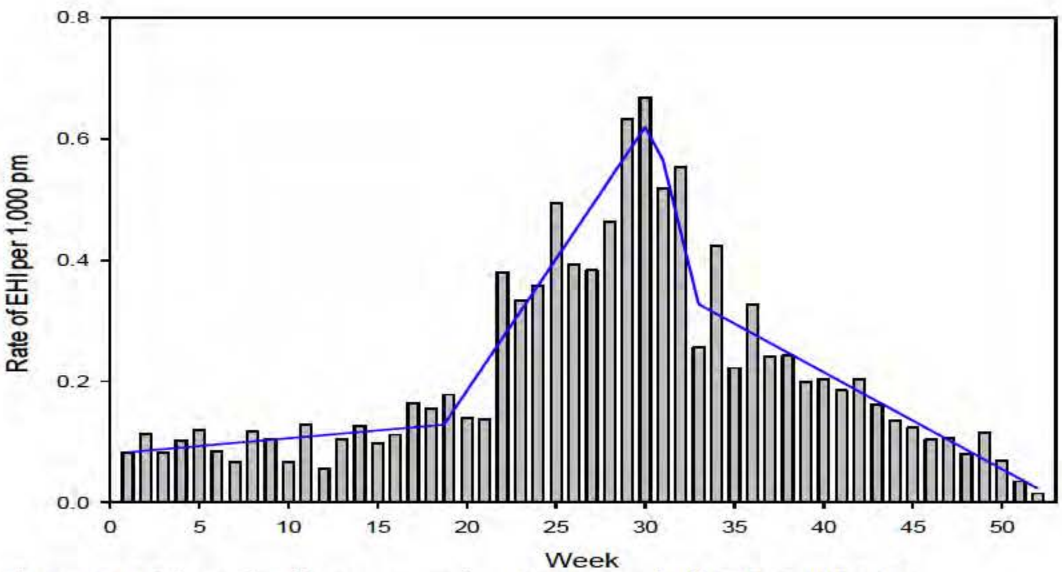


Figure 11C Piecewise linear regression, Fort Campbell, KY, 2008-2012

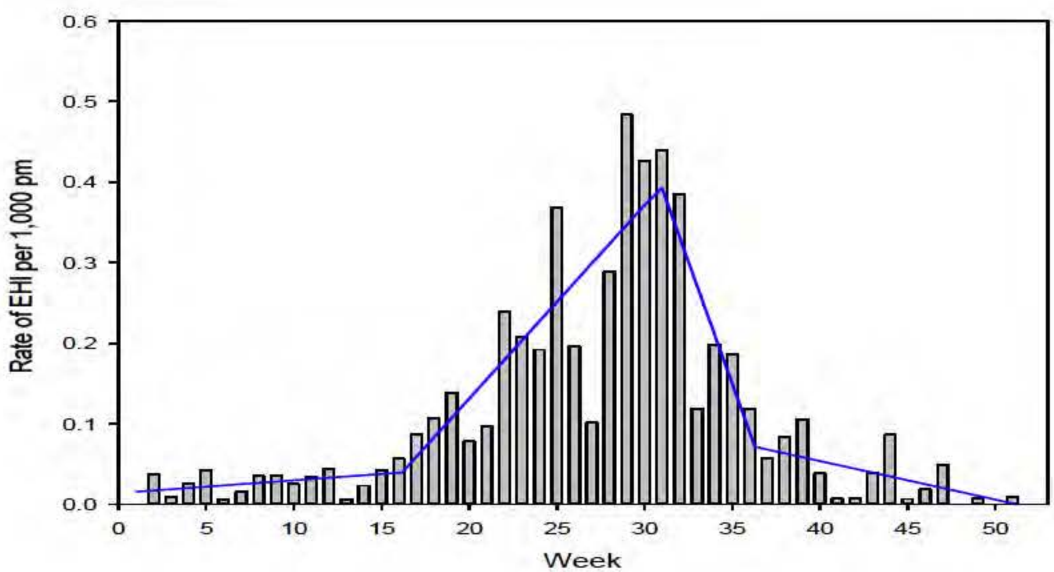


Figure 11D Piecewise linear regression, Fort Hood, TX, 2008-2012

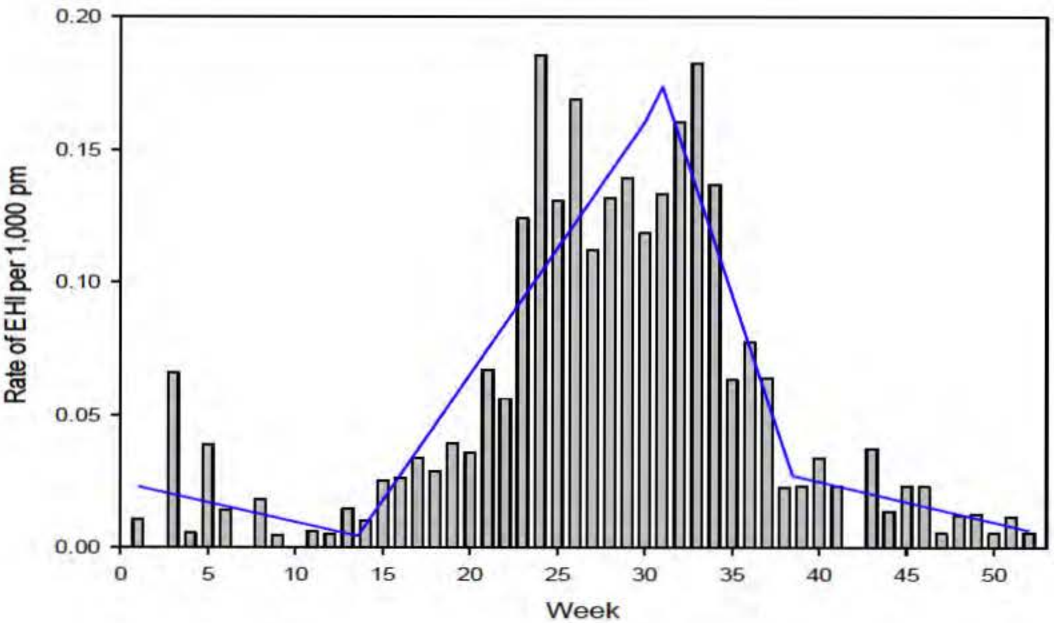


Figure 11E Piecewise linear regression, Fort Jackson, SC, 2008-2012

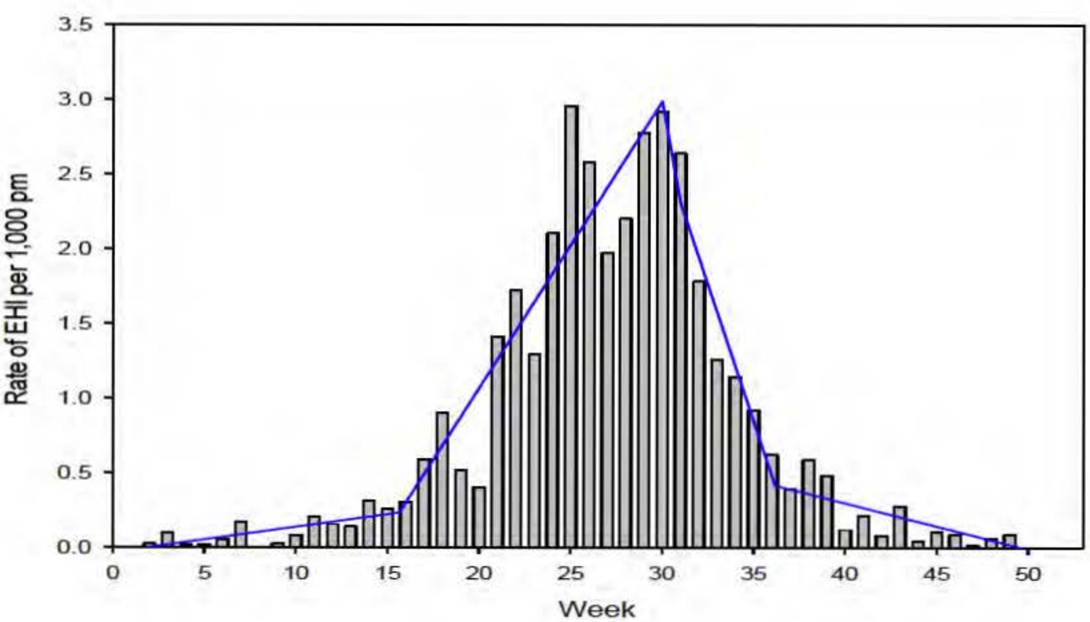


Figure 11F Piecewise linear regression, Fort Leonard Wood, MO, 2008-2012

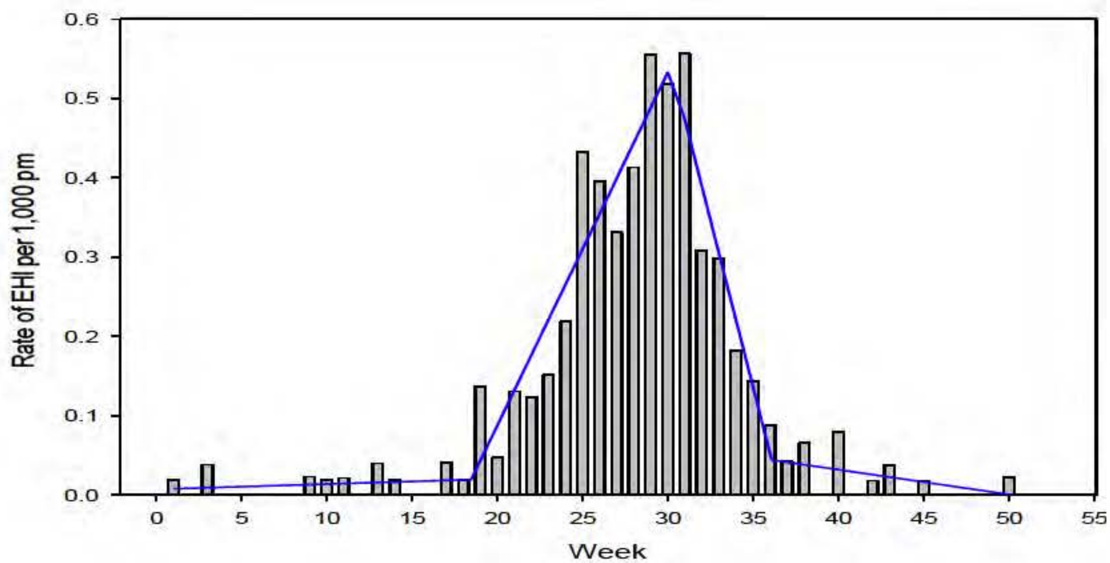


Figure 11G Piecewise linear regression, Fort Polk, LA, 2008-2012

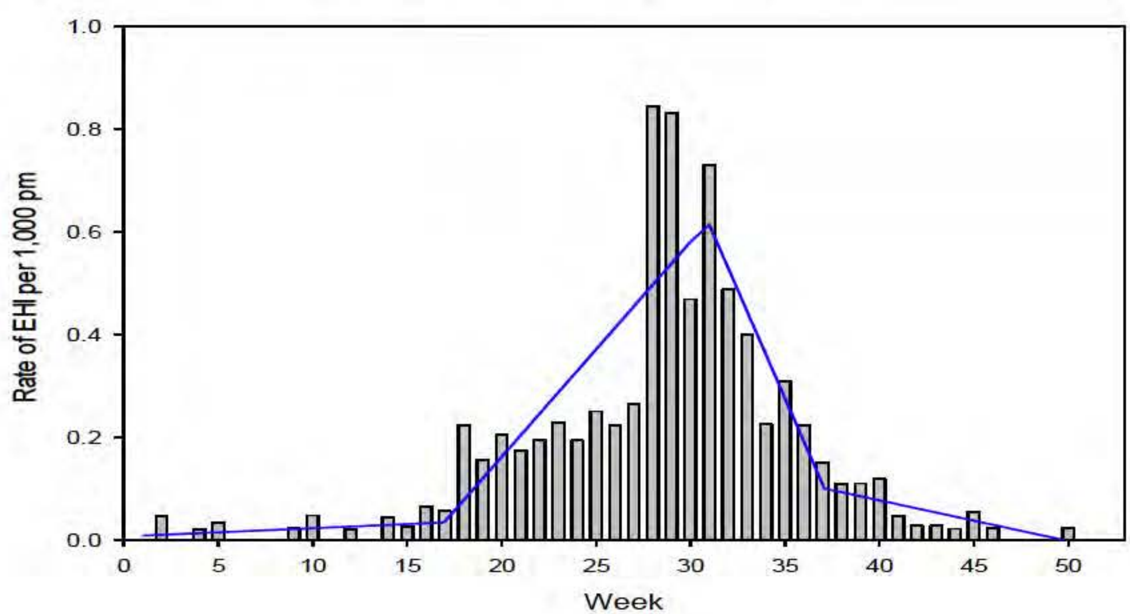


Figure 11H Piecewise linear regression, Fort Riley, KS, 2008-2012

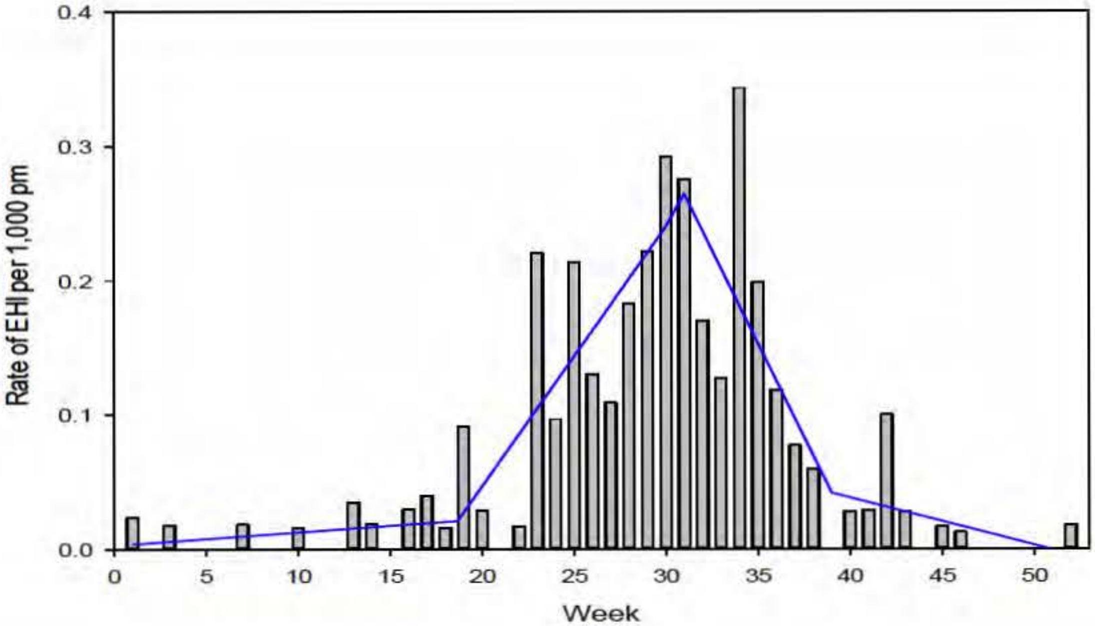


Figure 11I Piecewise linear regression, Fort Sill, OK, 2008-2012

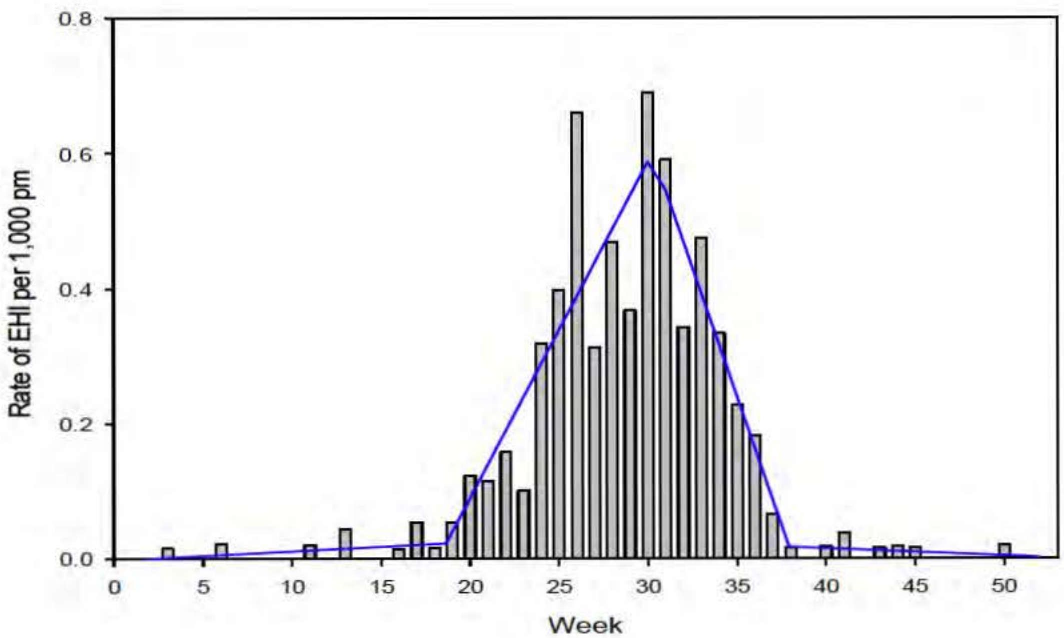
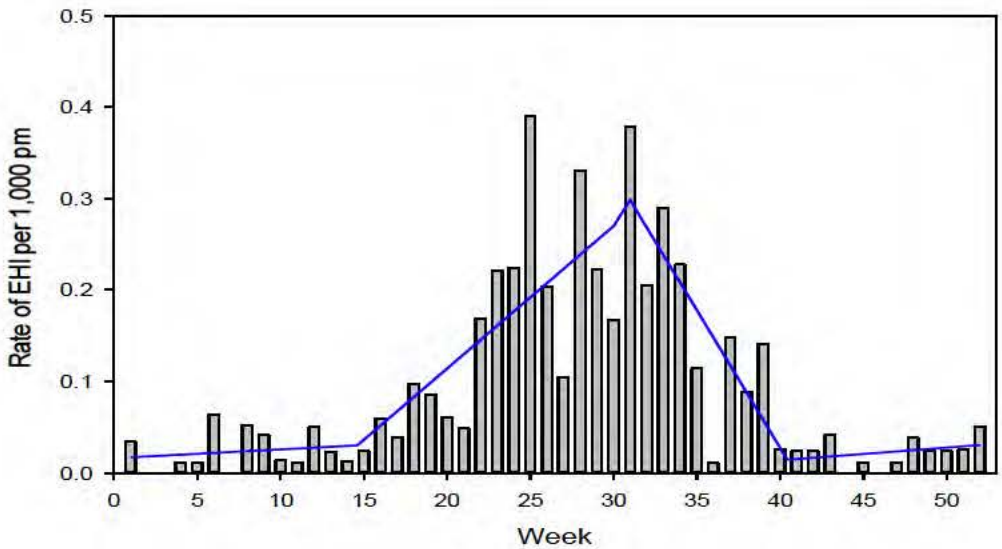


Figure 11J Piecewise linear regression, Fort Stewart, GA 2008-2012



6.6 Injury Data from Soldiers with Repeat EHIs

There were a total of 629 Soldiers with two or more "new" EHIs during the investigation period. Males represented 78.8% of the total population in this sample but 86.6% of those with a repeat EHI, which was significantly different from the female proportions (21.2% and 13.4%, respectively; chi square 25.551, $p<0.001$). Soldiers with repeat EHIs during the investigation period were more likely to be aged 20 to 29, white, non-Hispanic, ranked E1-E4 (69.8%), and located at Fort Bragg (63.0%) at the time of injury diagnosis. The most common primary injury diagnosis of Soldiers with repeat EHIs was heat stroke and sun stroke (41.8%, ICD-9 992.0) or heat exhaustion (32.6%, ICD-9 992.3 through 992.5).

Table 6.5 Demographics of Soldiers with Repeat EHIs, 2008-2012, (n=629)

Variable	Variable Level	n	% injured
Sex	Male	545	86.6
	Female	84	13.4
Age	<20	44	7.0
	20-29	450	71.5
	30-39	115	18.3
	40+	20	3.2
Race/Ethnicity	Unknown	18	2.9
	White, non-Hispanic	404	64.2

	Hispanic	46	7.3
	Black, non-Hispanic	129	20.5
	Asian/Pacific Islander	32	5.1
Rank	E1-E4	439	69.8
	E5-E9	133	21.1
	O1-O5	55	8.7
	O6-O10	0	0.0
	W1-W5	2	0.3
Unit Location	Fort Benning	53	8.4
	Fort Bragg	396	63.0
	Fort Campbell	38	6.0
	Fort Hood	35	5.6
	Fort Jackson	32	5.1
	Fort Leonard Wood	6	1.0
	Fort Polk	20	3.2
	Fort Riley	14	2.2
	Fort Sill	7	1.1
	Fort Stewart	28	4.5

7 Discussion

The purpose of this project was to examine the within-season trends for exertional heat illness at US Army installations that historically have the highest EHI frequency. The 'heat season' has been operationally defined as occurring from 1 May to 30 Sept (2), during which time the incidence of EHI is expected to be greatest. Prior to the present public health report, there were no data supporting or refuting the arbitrary heat season definition, nor were there data documenting the proportion of EHI that occurred within or outside the boundary dates of the defined heat season.

7.1 Injury trends by location

Our analysis indicates that 82.3% of EHI in this population occurred within the heat season. However, there was considerable variability between locations, with Ft Bragg registering the lowest proportion (70.1%) of within-season EHIs and Ft Sill the highest proportion (95.3%; see Table 6.3). Inspection of Figures 6.5 and 6.9A-J does not suggest any readily apparent climatic differences between locations. The effect of local EHI mitigation policies and procedures on the between-location variability is unknown. While similar guidance is provided across the Army(3, 9), how consistently or effectively these guidelines are implemented is unknown. An additional confounder factor that makes comparison between locations difficult is the numerous demographic differences between

the Soldier populations at each location (airborne vs field artillery, FORSCOM vs TRADOC units, mixed populations).

7.2 Alternative heat season definitions

In order to determine if different start and end dates of the heat season would improve the proportion of within-season EHIs, we explored 4 alternatives. First, we applied the average segmental regression analysis breakpoints for all locations combined (weeks 17 and 37), which lowered the within-season proportion to 78.7%. Next, we used week 17 as the start of the season but retained the original week 39 end-of-season breakpoint, which marginally increased the within-season proportion to 83.9%, compared to 82.3%. Additionally, we applied the earliest (week 14/April 2-8, Ft Hood) and the latest breakpoints (week 41/October 8-14; Ft Stewart) and estimated that this definition of the heat season would raise the proportion to 88.5%. Considering that 27.2% of all EHI in this sample occurred at Ft Bragg, and that 29.9% (~630 incidents, or 8% of the entire sample) of those occurred outside of the heat season, further improvement is not likely. Lastly, we removed all EHI cases at Ft Bragg from the sample population and re-calculated the within-season proportion, using the original 1 May and 30 September definition of the heat season (weeks 18 and 39). This approach demonstrated that 86.9% of EHI occurred within the heat season, 8.4% before and 4.7% after, which further illustrates the influence of the population size and of the non-heat season frequency of EHI at Ft Bragg. We conclude that revising the dates defining the heat season is not warranted and that greater emphasis year-round on heat illness prevention at Ft Bragg is indicated.

At the ten bases investigated between 2008 and 2012, EHIs occurred most frequently among white, non-Hispanic (56.9%), male (78.8%) Soldiers aged 20-29 (59.6%) and ranked E4 or lower (77.4%). These findings are similar to other military surveillance reports of heat injuries among the active component of the U.S. Armed Forces.(5, 7) The small differences in EHIs distribution between this investigation and Medical Surveillance Monthly Reports (MSMR) data are likely due to the fact that MSMR reports are generated using surveillance data from all active component members of the U.S. Armed Forces, while this investigation focused specifically on EHIs among U.S. Army Soldiers. An investigation of hospitalizations and deaths from heat illness in U.S. Army Soldiers between 1980 and 2002 revealed a slightly higher frequency of EHI encounters among male (86.3%) and white, non-Hispanic (66.7%) Soldiers.(7) During the five year study period, Fort Bragg, Fort Benning, and Fort Jackson had the highest frequency and rate of new heat injuries. According to recent MSMR data Ft Bragg, followed by Fort Benning and Fort Jackson, had the greatest frequency of EHIs in each year.(5) In our analyses, the 7 remaining installations accounted for only 33% of the total number of EHI during the study period. These differences show that some U.S. Army bases have a much larger burden of EHIs than other bases. As noted above, speculation regarding the cause(s) of these differences is confounded by the nature of the populations and activities at each location.

7.3 Exertional heat stroke

Our data indicate that 13.6% of the EHI in this sample were heat stroke (Table 6.3), which is slightly lower than the 18% reported elsewhere.(7) In addition to the difference time periods covered by each of the investigations, this nominal difference is likely due to the inclusion of outpatient EHI casualties in the present analysis, while the study by Carter et al only included hospitalizations.(7) However, caution is warranted when interpreting the by-location exertional heat stroke data presented in Table 6.3. While such disparate percentages are possible, due to differences in the Soldier population (predominantly TRADOC vs FORSCOM units) and/or command emphasis on EHI prevention, other factors may contribute as well. The spectrum of heat illnesses are on a continuum, ranging from relative minor heat exhaustion (ICD-9 code 992.3 – 992.5) to more severe heat injury and most severe exertional heat stroke (ICD-9 992.0). There is not an ICD-9 code for heat injury however OTSG/MEDCOM Policy Memo 09-039 Heat Illness Medical Evaluation Board and Profile Policy specified that ICD-9 992.8 Other specified heat effect should be used for these cases. Unfortunately when the contents of this policy memo were incorporated into a revision of AR 40-501 Standards of Medical Fitness, the paragraph specifying which ICD-9 code to use was not included.(10) This lack of direction may lead healthcare providers to choose an ‘incorrect’ ICD-9 code, thereby limiting our ability to interpret trends or differences between locations. Additionally, historically heat stroke was often diagnosed based primarily on body core temperature >41.1°C (106°F).(13) However, the contemporary definition states that heat stroke is characterized by central nervous system dysfunction, usually but always >40°C.(21) In the exercise science community there is an accumulating body of evidence that individuals may have post-event body core temperature >40°C yet be asympomatic regarding exertional heat illness(11, 14, 16) which reinforces the notion that body core temperature should not be the primary diagnostic criteria for exertional heat stroke. Taken together, these factors suggest that caution is warranted when examining trends or differences in the frequency and incidence rates of the different types of exertional heat illnesses.

7.4 Prior EHI as a risk factor

History of a prior heat illness is often cited as a risk factor for future heat illness (4, 6, 9) and in this study there were 629 Soldiers who experienced more than one “new” EHI. Repeat “new” EHIs occurred most frequently among white, non-Hispanic male Soldiers that were aged 20-29, and ranked E1-E4. Fort Bragg had the largest number (63%) of repeat “new” EHIs. The most common diagnosis among repeat EHI cases was heat stroke (41.8%, ICD-9 992.0). It is possible than many of the repeat cases were not actually new EHIs but were follow up visits for more severe heat injuries. Depending on the severity of the injury and extent of organ damage, heat stroke patients may require numerous follow-up visits; accordingly we employed a ’60-day rule’, in which multiple visits within 60 days of an initial diagnosis for a given individual was considered a follow-up visit and discarded prior to data analysis. However, as AR 40-501 specifies a 2 month minimum profile for

heat stroke cases with sequelae, it is possible that some individuals had a follow-up visit more than 60 days after the initial event, leading to over-estimation of the number of repeat EHI. There is evidence from animal models of heat stroke demonstrating that organ and/or tissue damage may persist after conventional laboratory biomarkers have returned to baseline.(15, 19) These data suggest that a prior heat illness does increase the risk of an individual experiencing a future heat illness, but laboratory or epidemiological data from humans are lacking and further research is warranted.

8 Conclusions and Recommendations

As a result of our analysis, we conclude that the current heat season definition of 1 May – 30 September is appropriate and that altering it is not warranted at this time. However, as ~17% of all EHI occur outside of the heat season, we recommend that the year-round risk of EHI be included in future heat injury prevention guidance, memorandums and doctrine. Further investigation is warranted regarding ICD-9 diagnostic codes and healthcare providers should be updated on the diagnostic criteria and associated codes for the continuum of heat illnesses.

9 Point of Contact

The point of contact is MAJ David DeGroot and the US Army Public Health Command Injury Prevention Program, who can be reached at usarmy.apg.medcom-phc.mbx.injuryprevention@mail.mil or phone number 410-436-4655, DSN 584-4655

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Appendix B

Week	Dates	Month
1	Jan 1-7	1
2	Jan 8-14	1
3	Jan 15-21	1
4	Jan 22-28	1
5	Jan 29-Feb 4	2
6	Feb 5-Feb 11	2
7	Feb 12-Feb 18	2
8	Feb 19-Feb 25	2
9	Feb 26-March 4	3
10	March 5-March 11	3
11	March 12-March 18	3
12	March 19-March 25	3
13	March 26-April 1	3
14	April 2-April 8	4
15	April 9-April 15	4
16	April 16-April 22	4
17	April 23-April 29	4
18	April 30-May 6	5
19	May 7-May 13	5
20	May 14-May 20	5
21	May 21-May 27	5
22	May 28-June 3	5
23	June 4-June 10	6
24	June 11-June 17	6
25	June 18-June 24	6
26	June 25-July 1	6
27	July 2-July 8	7
28	July 9-July 15	7
29	July 16-July 22	7
30	July 23-July 29	7

Week	Dates	Month
31	July 30-Aug 5	8
32	Aug 6-Aug 12	8
33	Aug 13-Aug 19	8
34	Aug 20-Aug 26	8
35	Aug 27-Sept 2	8
36	Sept 3-Sept 9	9
37	Sept 10-Sept 16	9
38	Sept 17-Sept 23	9
39	Sept 24-Sept 30	9
40	Oct 1-Oct 7	10
41	Oct 8-Oct 14	10
42	Oct 15-Oct 21	10
43	Oct 22-Oct 28	10
44	Oct 29-Nov 4	10
45	Nov 5-Nov 11	11
46	Nov 12-Nov 18	11
47	Nov 19-Nov 25	11
48	Nov 26-Dec 2	11
49	Dec 3-Dec 9	12
50	Dec 10-Dec 16	12
51	Dec 17-Dec 23	12
52	Dec 24-Dec 31.	12

Appendix C-ICD-9 Codes

EHI ICD-9 Codes

992	Effects of heat and light
992.0	Heat stroke and sunstroke
992.1	Heat Syncope
992.2	Heat cramps
992.3-.5	Heat exhaustion (anhidrotic, salt depletion, unspecified)
992.6	Heat fatigue transient
992.7	Heat edema
992.8	Heat effects other
992.81	Heat injury (new-Army requested)
992.89	Other unspecified heat effects
992.9	Effects of heat and light unspecified